ENVIRONMENTAL TOXICITY OF THE EXPLOSIVES RDX AND TNT IN SOIL TO THE SOIL INVERTEBRATE *FOLSOMIA CANDIDA*

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ABSTRACT

We investigated the toxicity of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and 2,4,6-trinitrotoluene (TNT) to the soil invertebrate *Folsomia candida* (Collembola) in five natural soils: Sassafras sandy loam (SSL), Teller sandy loam (TSL), Richfield clay loam (RCL), Kirkland clay loam (KCL), and Webster clay loam (WCL). According to the Ecological Soil Screening Level (Eco-SSL) criteria (USEPA 2003), relative bioavailability scores for organic chemicals in these soils were considered "high" for SSL and TSL; "medium" for RCL and KCL; and relatively "low" for WCL soil. We investigated whether soil type affects the toxicity of RDX or TNT in soil to Collembola by adapting a standardized *Folsomia* reproduction test (ISO 11267:1998). Adult survival and juvenile production by *F. candida* were assessed using replicated multiple treatment concentrations and appropriate controls. Juvenile production data were analyzed using nonlinear regression models. Initial EC_{20} and EC_{50} values [mg kg^{-1}] for juvenile production in freshly amended soils were, respectively for RDX: 7 and 30 (TSL), 16 and 55 (RCL), 28 and 90 (SSL), 31 and 110 (KCL), 3 and 50 (WCL); and for TNT: 7 and 17 (TSL), 4 and 23 (RCL), 17 and 25 (SSL), 21 and 37 (KCL), 174 and 259 (WCL). These provisional results indicate that the soil with highest organic matter and clay contents (WCL) sustained the least TNT toxicity, while soil with lowest organic matter and clay contents (TSL), sustained the greatest TNT toxicity to *F. candida* reproduction based on EC_{50} values. Correlation analysis showed relatively week relationships overall among the soil properties and toxicity endpoints for RDX.

1. INTRODUCTION

Objective Force Soldiers must be highly trained in all tasks across the spectrum of military operations. These Soldiers will need demanding, highly realistic training to obtain this capability. This increased training will lead to an increased release into the environment of explosives at training sites. Soil contamination was identified at more than 21,000 sites among Department of Defense (DoD) installations (Bridges and Whaley, 1997). By 2001, the number of known waste sites on current and former DoD installations in the United States exceeded 28,000. Many of these sites associated with military operations that involve munition manufacturing, disposal, testing, and training, contain elevated levels of explosives and related materials in soil.

We adapted the standardized Collembola Reproduction Test to measure the toxicity of RDX and TNT to this ecologically relevant test species. This chronic assay includes at least one reproductive component among the measurement endpoints.

Soils with a relatively wide range of physical/chemical characteristics were tested, including: Sassafras sandy loam (SSL), Teller sandy loam (TSL), Richfield clay loam (RCL), Kirkland clay loam (KCL), and Webster clay loam (WCL).

2. RESULTS AND DISCUSSION

The effect of RDX or TNT on adult survival of *F. candida* varied among freshly amended soil types tested. RDX toxicity measured as adult *F. candida* mortality was highest in TSL and lowest in SSL. The greatest TNT toxicity to adult *F. candida* was found in the soil with lowest organic matter and clay contents (TSL), and was lowest in the soil with highest organic matter and clay contents (WCL).

The EC_{20} and EC_{50} values (mg kg^{-1}) for juvenile production in freshly amended soils were, respectively for RDX: 7 and 30 (TSL), 16 and 55 (RCL), 28 and 90 (SSL), 31 and 110 (KCL), 3 and 50 (WCL); and for TNT: 7 and 17 (TSL), 4 and 23 (RCL), 17 and 25 (SSL), 21 and 37 (KCL), 174 and 260 (WCL).

Preliminary results based on EC_{50} values indicate that the soil with highest organic matter and clay contents (WCL) sustained the least RDX or TNT toxicity to *F. candida* reproduction, while soil with lowest organic matter and clay contents (TSL)

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sustained the greatest RDX or TNT toxicity to *F. candida* reproduction. However, the soils having intermediate levels of organic matter and clay contents were not as consistent in their modification of the resulting RDX or TNT toxicities to *F. candida*.

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CONCLUSION

The overall results indicate that soil physical and chemical properties may alter the toxicity of RDX and TNT. This is shown by different dose responses by *F. candida* exposed to the same concentrations of either RDX or TNT in soils having different characteristics. However, based on the relative differences in the modification of RDX or TNT toxicities to *F. candida* in soils having intermediate levels of organic matter and clay contents, ecological assessments of risk should not be based solely upon any single bioassay.